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I. V. Kapalin (Moscow, Lomonosov Moscow State University (MSU)). **Application of LQR to vertical stabilization problem with several actuators.**

The problem of vertical plasma stabilization is considered. The work is of interest in analysis of an actuator influence on control system. The actuator in the tokamak is nonlinear transformation, so control synthesis is done for linear system without actuator with regular technics with account that control system would be used with the actuator. This work is prolongation of the [1].

The synthesis of the control system consists in the synthesis of SISO regulator and MIMO regulator. The linearized model of vertical plasma motion is

$$\begin{cases} \dot{x} = Ax + Bu, \\ y = Cx + Du, \end{cases} \tag{1}$$

where $x \in \mathbf{R}^{30}$ — vector of currents in coils and passive elements of tokamak, $y \in \mathbf{R}^9$ — vector of measurement parameters of tokamak (velocity $\widehat{\dot{\xi}}$ and position $\widehat{\xi}$ of plasma filament center; $I_{coils} \in \mathbf{R}^8$ currents in coils), $u \in \mathbf{R}^8$ — voltage vector, denote $u = (\overline{u}^T,\ u_{HFC})^T$; A, B, C и D — matrixes computed by program $TokScen$ [2] and $DINA-L$ [3] for tokamak KTM. A feature of the model is an one stable eigenvalue of the matrix A, corresponding to a vertical plasma instability, the system is controllable and observable with control $\overline{u}$ and output I_{coils}, that one allows to use LQR method.

SISO regulator transfer function is $R_p(s) = -k$, where parameter k is selected from the criterion of maximizing the degree of stability η [p. 127–129, 4] closed system with control $u_{HFC}(t) = -k\widehat{\dot{\xi}}(t)$, while $\overline{u} \equiv 0$.

LQR controller [p. 336–338, 5] is constructed in a pair of Luenberger observer whose output $\widetilde{x}$ is an estimation of the vector x, MIMO regulator is $\overline{u} = -K_{LQR}\widetilde{x}$. In the synthesis of the regulator used a quadratic integral criterion of the form

$$J(u) = \int_0^\infty ||I_{coils}||^2 + \alpha^2\dot{\xi} + \beta^2\xi + \gamma^2||\overline{u}||^2 dt.$$

There are positive parameters α^2, β^2 and γ^2 implicitly determine the amplitude of the velocity $\dot{\xi}$, the position ξ and the control $\overline{u}$.

The synthesis of stable control system was done, it was simulated in MatLab with two models of the actuators (pulse-width modulation model and Matlab model of thyristor) and with two variants of matrix A, B, C and D (computed by $TokScen$ and $DINA-L$ code). Turns out that actuator are not creating significant influence on control system, but taking into account the actuator at the control synthesis will obviously facilitate control over the shape of the plasma.

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